

GEOGRAPHICAL AND PHYSICAL SETTINGS

The State of New Hampshire has two important estuaries along its approximately 220 miles of tidal shoreline. The Great Bay Estuary, the largest in New Hampshire, is a drowned river valley that is similar to some of the estuaries found along the Maine coast. The Hampton/Seabrook Estuary is a bar-built estuary situated behind barrier beaches and surrounded by expansive areas of salt-marsh. Though quite different in size, topography of the watershed, geomorphology, hydrodynamics, and ecology, the Great Bay and Hampton Harbor estuaries can have similar geographically-related problems. It is for this reason that these areas are collectively the main foci of the New Hampshire Estuaries Project.

Both estuaries have been studied by several organizations that include the University of New Hampshire, Jackson Estuarine Laboratory (JEL), N.H. Fish and Game Department (NHF&G), NH Department of Environmental Services (NHDES), N.H. Office of State Planning (NHOSP), New Hampshire Department of Health and Human Services (NHDHHS), Normandeau Associates, Inc. and the U.S. Fish and Wildlife Service. Substantial historic databases are available on the physical and chemical properties of these estuaries, including sedimentology, hydrography and nutrient concentrations. There are also extensive inventories of seaweed species, estuarine fish and invertebrates as well as standing crop and distributional data for seagrasses and marsh plants. There are numerous data layers for the area digitized on the state Geographic Information System (GIS), including hydrography, land cover, land use, point sources of pollution, potential nonpoint threats, bathymetry, wetlands and intertidal macroalgae, and several others. Monitoring data as well as other research efforts in Great Bay have been reviewed in a document entitled "The Ecology of the Great Bay Estuary, New Hampshire and Maine: An Estuarine Profile and Bibliography" (Short, 1992). This document summa-

rized the research and management efforts in the Great Bay Estuary as of 1991 and provides references for detailed information. An extensive body of work on the Hampton Harbor Estuary was compiled as part of the Environmental Impact Statement for the construction and operation of the Seabrook nuclear power plant. Monitoring efforts continue today both in the estuary and offshore at the cooling intake and outfall sites. The Hampton Harbor Sanitary Survey (NHDHHS, 1994), a result of the 1993 CORD Shellfish Taskforce's efforts, describes water circulation, bacterial contamination and the effect of storms and tidal conditions in the estuary.

1.1.1 THE GREAT BAY ESTUARY

The Great Bay Estuary is a tidally dominated, complex embayment on the southern New Hampshire-Maine border (Figure 1.2). The estuarine tidal waters cover approximately 17 square miles (10,900 acres), with a 144-mile shoreline of steep wooded banks with rock outcroppings, cobble and shale beaches, and fringing saltmarsh. The estuary extends inland from the mouth of the Piscataqua River between Kittery, Maine, and New Castle, New Hampshire through Little Bay to Great Bay proper, a distance of 25 km or 15 miles (Brown and Arellano 1979). The junction of Little Bay and the Piscataqua River occurs at Dover Point. Little Bay turns sharply at Cedar and Fox Points near the mouth of the Oyster River and ends at Furber Strait near Adams Point. Great Bay begins immediately inland or "upstream" of Furber Strait. With the exception of the eastern shore of the Piscataqua and Salmon Falls rivers which are bordered by southern York County, Maine, the estuary is entirely in Strafford and Rockingham Counties of New Hampshire. New Hampshire municipalities on the shores of the estuary include Portsmouth, Newington, Dover, Rollinsford, Madbury, Durham, Newmarket, Newfields, Exeter, Stratham and Greenland.



FIGURE 1.2

*The Great Bay and
Hampton/Seabrook
Harbor estuaries
and surrounding
municipality
boundaries*



S. MIRICK

Great Bay

The largest cities in the watershed include Rochester, Dover, Portsmouth, and Exeter and have estimated populations of 28,726, 26,200, 22,830, and 13,258, respectively (NHOSP, 1997). Data on current and projected population and population density for all towns in Strafford and Rockingham Counties are presented in Appendix A.

Two-thirds of the 930 square mile Piscataqua River drainage basin is located within New Hampshire, with the remainder in southern Maine (Reichard and Celikkol, 1978). Tidal waters from the Atlantic Ocean enter the estuarine system at Portsmouth Harbor, flooding the three major portions of the Estuary; the Piscataqua River, Little Bay and Great Bay. The estuary derives its freshwater inflow from seven major rivers, four of which are gauged by the U.S. Geological Survey (USGS) (the Lamprey, Oyster, Cocheco, and Salmon Falls rivers). The Lamprey, Squamscott and Winnicut rivers flow directly into Great Bay. The Salmon Falls, Cocheco, Bellamy, and Oyster rivers flow into the estuary between Furber Strait and the open coast. River flow varies seasonally, with the greatest volumes occurring as a result of spring runoff. However, the tidal component in the estuary dominates over freshwater influence throughout most of the year.

Freshwater input typically represents only 2 percent or less of the tidal prism volume (Reichard and Celikkol, 1978; Brown and Arellano, 1979), but the percentage varies seasonally. Estimates of flow for all rivers (Appendix B) suggest that the average combined freshwater inflow is greater than 1000 cubic feet per second. Approximately 50 percent of the average annual precipitation (42 inches) in the Great Bay Estuary drainage basin enters the estuary as stream flow (NHWSPPCC, 1975).

Tidal height ranges from 2.7 m at the mouth of the estuary to 2.0 m at Dover Point, increasing slightly to 2.1 m at the mouth of the Squamscott River. The phase of the tide lags significantly moving up the Great Bay Estuary from the ocean and the slack tides can be as much as 2.5 hours later in the Squamscott River than at the mouth of the estuary. Strong tidal currents and mixing limit vertical stratification during most of the year throughout the estuary. Partial stratification may occur during periods of intense freshwater runoff, particularly at the upper tidal reaches of rivers entering the estuary. The large tidal range during spring tides results in exposure of extensive mudflats along the fringing areas of the Piscataqua River, Little Bay and the tributaries as well as large expanses of

exposed tidal flats in the central part of Great Bay. High summer temperatures in these shallow flats can reach 30°C in the summer and -2°C during the coldest part of winter when much of Great Bay can freeze over. Ice scour in winter and early spring can play a major role in both sediment transport and disturbances to submerged aquatic vegetation and benthic fauna.

The observed flushing time for water entering the head of the estuary is 36 tidal cycles (18 days) during high river flow (Brown and Arellano, 1979). Tides cause considerable fluctuations of water clarity, temperature, salinity and current speeds, and have a major impact on bottom substrata. Shallow areas of the estuary are also greatly affected by wind-wave conditions which can influence grain size distributions and sediment transport throughout the estuary. Waves resuspend sediments, increasing turbidity levels well above levels attributed to tidal currents alone (Anderson, 1972). A horizontal gradient of decreasing salinity exists from the mouth of the harbor to the tidal reaches of the tributaries and the upper portions of Great Bay. The range of this gradient (0-30 ppt) depends on tidal cycle, season and rainfall conditions.

The Great Bay Estuary has a variety of different habitats including approximately 1,000 acres of saltmarsh, 52 acres of major oyster beds, 2,575 acres of scattered clam flats, 5,000 acres of subtidal eelgrass, extensive intertidal and subtidal macroalgal cover, mudflats and rocky outcroppings and islands. The subtidal substrate in the lower estuary is primarily rock and cobble, with sand and mud-sand mixture in the intertidal and nearshore subtidal areas. Some hard substrate can be found in channel areas of the upper estuary and tidal rivers, but the dominant substrata are sandy mud and silt. Because of this habitat diversity, Great Bay Estuary supports a wide variety of flora and fauna described in more detail in Chapter 3: Living Resources.

Land cover for the watershed of the Great Bay Estuary, mapped using 1988

and 1990 LANDSAT Thematic Mapper imagery, has been digitized on the state GIS system. Land cover shows the watershed is primarily forested, with smaller percentages of other land cover categories (Table 1.1, Appendix C). Most of the urban land is concentrated in the municipalities of Rochester, Dover, Portsmouth, and Exeter.

Land use information for the watershed, developed in the 1980s and early 1990s by Rockingham and Strafford Regional Planning Commissions, has also been mapped and digitized on the state GIS system (Appendix C). Land use surrounding the Great Bay Estuary ranges from urban/industrial near the mouth of the Piscataqua River and in the cities and towns located at the head of tide of each of the tributaries, to rural, residential and undeveloped private and public lands. The Portsmouth Naval Shipyard, a major military base, is located on Seavey Island in Portsmouth Harbor, and the former Pease Air Force Base in Newington and Portsmouth is currently under commercial development as the Pease International Tradeport. A portion of the estuary is part of the National Oceanic and Atmospheric Administration's (NOAA) National Estuarine Research Reserve Program and is managed by NH Fish and Game Department. Just over 1,000 acres of the former Pease Air Force Base are now the Great Bay National Wildlife Refuge, managed by the U.S. Fish and Wildlife Service. Land and shoreline ownership around the Great Bay Estuary and throughout its tidal waters is predominantly private, with some lands protected or in government ownership (Short and Webster, 1992). For lands within 300 feet of the tidal waters of the Great Bay Estuary system, 38% is developed, 18% is permanently protected, 7% is undevelopable and 37% is developable (Rubin and Merriam, 1998). Acquisition of lands for conservation easements is an ongoing process, with both government (U.S. Fish and Wildlife Service, N.H. Fish and Game Department, Great Bay National Estuarine Research Reserve) and private programs operating.



MORRISON

*The Hampton/
Seabrook Estuary*

1.1.2 HAMPTON/SEABROOK ESTUARY

The Hampton/Seabrook Estuary is a tidally dominated, shallow, bar-built estuary located at the extreme southeast corner of New Hampshire (Figure 1.2). It is located entirely in Rockingham County and is bordered by the towns of Hampton, Hampton Falls and Seabrook. The Estuary is roughly rectangular in shape, has approximately 72 miles of tidal shoreline and has a total area at high tide of approximately 475 acres. The topography of the 47 square mile watershed is relatively flat with approximately 17 percent (5,000 acres) of saltmarsh. Eighty percent of the watershed is in New Hampshire, with the remainder in Massachusetts. There is one harbor entrance through which all tidal waters enter and exit. Tides are semi-diurnal with a mean tidal range of 2.5 meters and spring tidal range of 2.9 meters. During average wind conditions approximately 88 percent of the water in the estuary is exchanged on each tide (PSNH, 1973). The typical substratum is more coarse-grained than that found in the Great Bay Estuary, and more typical of a barrier system. The estuary receives freshwater input from the Taylor River and Hampton Falls River (which converge to form the completely tidal Hampton River) to the north; the Browns River and Mill Creek to the west; and the Blackwater

River to the south. Numerous small tidal creeks from the surrounding wetlands also drain into the estuary. River flows vary seasonally with the highest flows occurring in spring due to snowmelt and precipitation. Average annual precipitation is approximately 42 inches. Total mean freshwater discharge has been estimated to be 4.08 cubic ft/sec (NHDHHS, 1994a) and is minimal when compared to the average tidal flow of 22,000 cubic ft/sec. Water depth is relatively shallow, ranging at mean low tide from less than one meter in the tidal creeks and rivers to over six meters at the harbor entrance. Most of the harbor channels have a low tide depth of one to three meters.

During periods of light winds, the tidal flows dominate water circulation. Circulation can change considerably, however, in response to high wind and storms. Strong westerly and northwesterly winds alter tidal flows by forcing surface waters out of the mouth of the estuary, while during northeast storms, surface waters are pushed landward, impeding the seaward flow of ebb tide water (NAI, 1977). The estuary is generally well mixed with little vertical stratification, though some stratification does occur, particularly in the tidal rivers and creeks during high flow periods (NHDHHS, 1994a).

Perhaps the most striking feature of the Hampton/Seabrook Estuary is the

large expanse (5,000 acres) of contiguous salt marsh that surrounds the estuary. The estuary is also the most popular location in coastal New Hampshire for recreational harvesting of softshell clams. Mussels, lobsters, and a variety of finfish are also present. Sandy beaches both within and adjacent to the estuary are a major tourist attraction. Some of the last remaining sand dunes in coastal New Hampshire are located in the area. The Seabrook dunes, damaged by a series of coastal storms, were recently restored with sand and American beach grass.

Land cover for the Hampton/Seabrook Estuary Watershed, mapped using 1988 and 1990 LANDSAT Thematic Mapper imagery, has been digitized on the state GIS system (Table 1.1). Land cover shows the watershed is primarily forested, but not to the extent (on a percentage basis) of the Great Bay Estuary Watershed. A large amount of urban land is concentrated near the estuary in the Town of Hampton (estimated 1996 population of 13,003).

Land use information for the watershed, developed in the 1980s and early 1990s by Rockingham Planning Commissions, has also been digitized on the state GIS system (Appendix C). The Hampton Harbor area is the major summer resort area along the New Hampshire coast. Development bordering the estuary is primarily residential and concentrated in the beach areas on the eastern shore. Of the lands within 300 feet of the tidal waters of the Hampton/Seabrook Estuary, 14% are developed, 10% are permanently protected, 4% are developable and 71% are deemed undevelopable, pri-

marily because of the large expanse of salt marsh around the estuary.

Commercial development consists mostly of shops, hotels, and restaurants that support the tourist industry. The populations of both Hampton and Seabrook double in the summer to approximately 23,000. Total daily beach population, which includes daily visitors, vacationers at the hotels and motels (~30,000) and permanent and summer residents, can be as high as 100,000. Industrial activity in the watershed includes plastics, shoe and furniture manufacturing and metal fabrication. Most of these industries are small with the largest employing 1,000 people and total industrial employment at approximately 3,000. Seabrook nuclear power station, located on the western shore of the estuary, is a prominent feature.

1.1.3 BEACH AND DUNE SYSTEMS

The New Hampshire coast between the Great Bay and Hampton/Seabrook estuaries has significant areas of beaches and dunes. The beaches are heavily used in the summertime for bathing and surfing, and have experienced severe erosion during several recent storm events. The beaches and the rocky intertidal areas have been maintained to protect private and public properties and to provide conditions at the beaches that allow the economically-important tourist trade to remain viable. The historical extent of the dune areas has been drastically reduced by human development. Some of the remaining dunes, including those in Seabrook, have undergone some restoration.

Watershed land cover for the New Hampshire portions of the Great Bay and Hampton/Seabrook Harbor estuaries.

TABLE 1.1

CATEGORY	GREAT BAY ESTUARY		HAMPTON/SEABROOK ESTUARY	
	Acres	% of Total	Acres	% of Total
Forested	296,070	66	10,094	40
Wetland	44,703	10	5,392	21
Urban	43,944	10	5,800	23
Agriculture	28,418	6	2,039	8
Disturbed	8,494	2	380	2
Cleared	9,240	2	400	2
Water	17,211	4	1,030	4

BIOLOGICAL SETTING

New Hampshire's estuaries are composed of a variety of habitats. They serve as nursery areas for commercially important fish and shellfish species and sustain runs of numerous anadromous species. The primary producers include a diverse community from benthic diatoms to salt marshes and from microscopic phytoplankton to seaweeds and eelgrass. Along with the estuarine aquatic habitats, the surrounding terrestrial and wetlands areas support a variety of birds and mammals.

1.2.1 FISH AND SHELLFISH

Because of the diversity of habitats, New Hampshire's estuaries support an impressive array of living resources. The estuaries sustain runs of anadromous sturgeon, shad, alewives, lampreys, smelt and salmon that spawn in the freshwater portions of the rivers and streams. Freshwater areas of the rivers and streams in Hampton Harbor are directly accessible by anadromous fish, and in all the major rivers in the Great Bays Estuary, which were dammed in the 1800s for hydropower, fish ladders have been built

and maintained to allow anadromous species access to freshwater spawning areas. The estuaries also serve as nursery areas for commercially important species such as lobsters, winter flounders, cod, pollack, eels and hake. Both juvenile and adult striped bass can be found in increasing numbers between May and October as they forage on the abundance of baitfish such as silversides and smelt. The remarkable recovery of the east coast stocks of striped bass has been in part due to the availability of summer feeding areas such as Great Bay and Hampton Harbor. Berrys Brook in Rye, a tributary to the lower Piscataqua River, has a rare population of sea run brown trout. Shellfish are also abundant. There are 52 acres of oyster beds, over 2500 acres of scattered clam flats and significant areas with blue mussel beds, razor clams and scallops in Great Bay Estuary and its tributaries (Appendix D). Hampton Harbor supports abundant populations of softshell clams (approximately 2000 bushels) and blue mussels. An inventory of invertebrates and fish species is listed in Appendix E.





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1.2.2 BIRDS AND MAMMALS

A diverse bird population occurs within the estuaries of coastal New Hampshire, with as many as 110 species (excluding upland birds) observed using the estuaries. Coastal New Hampshire is part of the Atlantic flyway and is an important migratory stopover as well as wintering area for waterfowl. Seabirds, wading birds, shore birds, estuarine birds of prey, waterfowl and diving birds are found throughout the estuarine areas.

Seabirds (i.e. cormorants and gulls) are year-round residents of Great Bay. Herring gulls and great black-backed gulls are common within the estuary. The common tern (threatened in N.H.) nests in several areas of Great Bay and Hampton Harbor. Double-crested cormorants are present from April to November. Waterfowl, including black ducks and Canada geese, occur in fall and winter. Goldeneyes, scoters, scaups, buffleheads, mergansers and grebes are also seasonal visitors in Great Bay Estuary. A year-round population of mute swans, now totaling more than 60 birds, nests along the shores of Great Bay Estuary and spends the winter in the open waters of the bay. The great blue heron is the most prominent wading bird, occurring primarily from April to

October. Other wading species include snowy egrets, green herons, black-crowned night herons, glossy ibis, greater and lesser yellowlegs, and least sandpipers. Upland sandpipers are a rare species, though there is a nesting population adjacent to the runway at the Pease International Tradeport. Common terrestrial species include the American crow, belted kingfisher, ruffed grouse, and wild turkey.

Several endangered and threatened bird species, including bald eagles, common terns, upland sand pipers, marsh hawks, ospreys and common loons utilize part of Great Bay Estuary's diverse habitat at various times of the year. The estuary supports the largest winter population of bald eagles in New Hampshire. During recent winters up to fifteen eagles have occupied this wintering area simultaneously during early December through March. Ospreys, common loons and pied-billed grebes forage in the bay during migration; one osprey pair nested on the Bay in 1990, and more have nested since.

Mammals common to the Great Bay and Hampton/Seabrook estuaries include otters, minks, and beaver. Muskrats nest and overwinter in many areas of the bays and rivers, and harbor seals are frequently observed in fall, winter and spring.

Snowy Egret



Eelgrass

1.2.3 PRIMARY PRODUCERS

Primary producers in the Great Bay and Hampton/Seabrook estuaries include phytoplankton, benthic diatoms, salt-marsh plants, brown, red and green macroalgal species and eelgrass. Phytoplankton support a broad spectrum of planktonic consumers including bivalve, crustacean and fish larvae, as well as the large populations of sessile filter feeding invertebrates. Grazers such as snails, deposit feeding worms and other invertebrates feed on the benthic diatoms that grow on the exposed tidal flats.

Approximately 5,000 acres of eelgrass (*Zostera marina*) occurs in the Great Bay Estuary, though none occurs in Hampton Harbor. Eelgrass supplies the estuarine food web with organic matter, helps to stabilize sediment, and provides habitat for juvenile fish and invertebrates. Following substantial loss of eelgrass cover in the 1980s to an eelgrass wasting disease, eelgrass beds have expanded in the past several years and the populations appear to be in good condition. The importance of eelgrass beds is reflected in state and federal wetland regulatory actions that may require substantial mitigation, as was the case for the expansion of the Port of Portsmouth in 1993.

A total of 219 seaweed species are known from New Hampshire, including the Isles of Shoals (Mathieson and Hehre 1986, Mathieson and Penniman 1991). Of this total, 169 taxa (77.2% of total) are recorded from the Great Bay Estuary, including 45 Chlorophyceae, 46 Phaeophyceae and 78 Rhodophyceae. A vari-

ety of seaweed species occur within Great Bay that are absent on the open Atlantic coast north of Cape Cod. These species, which have a disjunct distributional pattern, may represent relict populations that were more widely distributed during a previous time when coastal water temperatures were warmer (Bousfield and Thomas 1975). Alternatively, they may have been introduced from the south. These seaweeds (e.g. *Gracilaria tikvahiae*, *Bryopsis plumosa*, *Dasya bailouviana*, *Chondria tenuissima*, *Lomentaria clavellosa*, *Lomentaria orcadensis* and *Polysiphonia subtilissima*) grow and reproduce during the warm summer and are able to tolerate colder winter temperatures (Fralick and Mathieson 1975, Mathieson and Hehre 1986). Several of these seaweed taxa and several invertebrates exhibiting this same pattern also occur in the Great Salt Bay at the head of the Damariscotta River in Maine, an area somewhat similar to Great Bay. The disjunct distributional pattern described for the seaweeds is also found for several marine/estuarine invertebrates (Bousfield and Thomas 1975, Turgeon 1976).

There are approximately 1,000 acres of saltmarsh in the Great Bay Estuary and over 5,000 acres of saltmarsh in the Hampton Harbor Estuary. Though these marshes are dominated by *Spartina alterniflora* and *Spartina patens*, a total of 69 species of plants have been identified in New Hampshire saltmarshes (Short and Mathieson, 1992). In addition to the rare and endangered birds previously mentioned, a number of rare and endangered plants are also found within the Great Bay Estuary. These species include the prolific knotweed (*Polygonum prolificum*), Eastern lilaeopsis (*Lilaeopsis chinensis*), Turks-cap lily (*Lilium superbum*), marsh elder (*Iva frutescens*), stout bulrush (*Scirpus robustus*), exserted knotweed (*Polygonum exsertum*), and the large saltmarsh aster (*Aster tenuifolius*). New Hampshire's saltmarshes have received a great deal of attention from resource managers over the past decade concerned about enhancing the functions of these important natural communities.



E. FINNERAN

The Great Bay and Hampton/Seabrook estuaries are extremely important to the local, regional, state, and national economies. From the time of first European settlement, the Great Bay Estuary was a center of commerce for natural resource based industries such as commercial fishing and logging. Virgin forests, bountiful runs of anadromous fish such as salmon, shad, sturgeon and river herring, as well as plentiful shellfish resources were the basis of a rapidly expanding economy. Plentiful timber and tidal water access to the towns gave rise to a large shipbuilding industry during the 1700s. Sailing barges called gundalows carried raw materials and manufactured goods to the towns in the estuary. During the 19th century, shoe and textile manufacturing became important and mills were built in all towns with access to navigable waterways. Increasing populations, lack of sewage treatment, pollution from sawmills and other industries, as well as unwise exploitation of natural resources, led to habitat degradation and declines in important fish and shellfish species. Abatement of pollution sources began in the 1940s and continues today, and the water quality and habitat areas have made a significant recovery.

Today there are varied commercial activities centered on the estuarine systems. Energy production facilities are located on the lower Piscataqua River as well as on the shore of Hampton Harbor. Shipping of lumber, mineral salt, gypsum, scrap metal, and other products occurs from the Port of New Hampshire in Portsmouth. The estuarine systems act as nursery areas for several species of fish that support local and regional fisheries in the Gulf of Maine. Although commercial fishing and shipping are important to the Gulf of Maine regional economy, tourism and recreation have become an increasingly important part of the New Hampshire Seacoast economy. The recreational industries supported by the activities described below are dependent on good water quality and a healthy ecosystem.

1.3.1 RECREATIONAL RESOURCES AND VALUES

Recreational activities in the Great Bay and Hampton/Seabrook estuaries are extensive and diverse, and have become a significant portion of the New Hampshire Seacoast economy. Boating, fishing, swimming, SCUBA diving, and other water sports are important recreational activities. Passive forms of recreation such as birdwatching and sight-seeing are also common.

1.3.1.1 Boating

Boating activities in the estuarine systems include sailing, fishing, water skiing, wind surfing, rowing, kayaking and canoeing. Boater registration records from 1993 indicate a total of almost 3,500 boats registered for tidal waters (note that the registration category is “fresh and tidal water” thus, not all of these boats are in the tidal waters all year). Just over 3,100 (90%) of these boats were in the “private/rental” class, while the remaining 10% were in the “charter/commercial” class (N.H. Dept. of Safety, 1994). During the 1980s, the Great Bay Estuary experienced a dramatic increase in boating activity as evidenced by the number of mooring permits issued by the state. The rate of increase leveled off following the adoption of the Harbor Management Plan.

Most of the approximately 1,400 moorings in N.H. tidal waters are used by pleasure boaters, with the rest of the mooring permits going to commercial boats and to commercial lease holders (marinas). The high demand for moorings is reflected in the length of the mooring waiting list, maintained by the N.H. Port Authority. There are currently almost 550 people waiting for a mooring, with the length of the wait ranging from three to 20 years, depending on the location requested (N.H. Port Authority, 1995).

1.3.1.2 Shellfishing

Shellfishing is also an important recreational activity in the estuaries. The Great Bay Estuary supports a large recreational shellfishery for oysters, clams and mussels. Oysters are the predominant shellfish resource utilized in Great Bay, although Little Harbor supports more concentrated populations of clams. Major oyster beds are located in Great Bay proper, as well as in the Piscataqua, Belknap, and Oyster rivers, with scattered pockets of oysters also found throughout the estuary (Figure 1.3). The estimated dollar value of oysters in major beds was nearly \$1.6 million in 1981 and \$3 million in 1994. Approximately 5,000 bushels of

oysters, valued at \$300,000 are harvested annually by the 1,000 license holders (Manalo et al., 1991). Recreational harvesting of shellfish in the Great Bay Estuary is currently limited to most of Great Bay and Little Bay, with the upper Piscataqua River, and the smaller tidal rivers closed to harvesting due to bacterial pollution (Figure 1.4). The harvesting of softshell and razor clams in Great Bay, though difficult, has become intensified because of the closure of more popular clamming areas such as the flats in Hampton and Little Harbors.

The principal shellfish resource in Hampton Harbor is the soft shell clam, located in five major resource areas (Figure 1.5). These flats had been closed since 1988, but with the conditional reopening of some of the flats in the fall of 1994 and further openings in 1995 and 1998 (Figure 1.6), almost 3,000 clamming licenses were sold in 1994 (up from 239 licenses in 1993). Prior to clam bed closures in 1988, the average number of licenses sold in the State between 1971-1987 was 6,400. The clam flats and mussel beds in Rye, Little and Portsmouth harbors, the lower Piscataqua River, the Back Channel and, in 1998, the open coast (Figure 1.7), remain completely closed to recreational harvesting (Figure 1.8). The contribution of recreational shellfishing to the local and state economy has been estimated to be \$3 million per year (Manalo et al., 1992).

1.3.1.3 Fishing

The Great Bay Estuary supports a diverse community of resident, migrant, and anadromous fishes, many of which are pursued by recreational fishermen. The most abundant species include Atlantic silverside, rainbow smelt, killifish, river herring, Atlantic tomcod, white perch, winter and smooth flounders. Year-round residents such as Atlantic silverside, killifish, Atlantic tomcod, winter flounder (juveniles), and smooth flounder are found throughout the estuary. Recreational fishermen pursue striped bass, bluefish, salmon, eels, tomcod, shad, smelt, and flounder. Fishing is not limited to boat access, as cast or bait fishing is

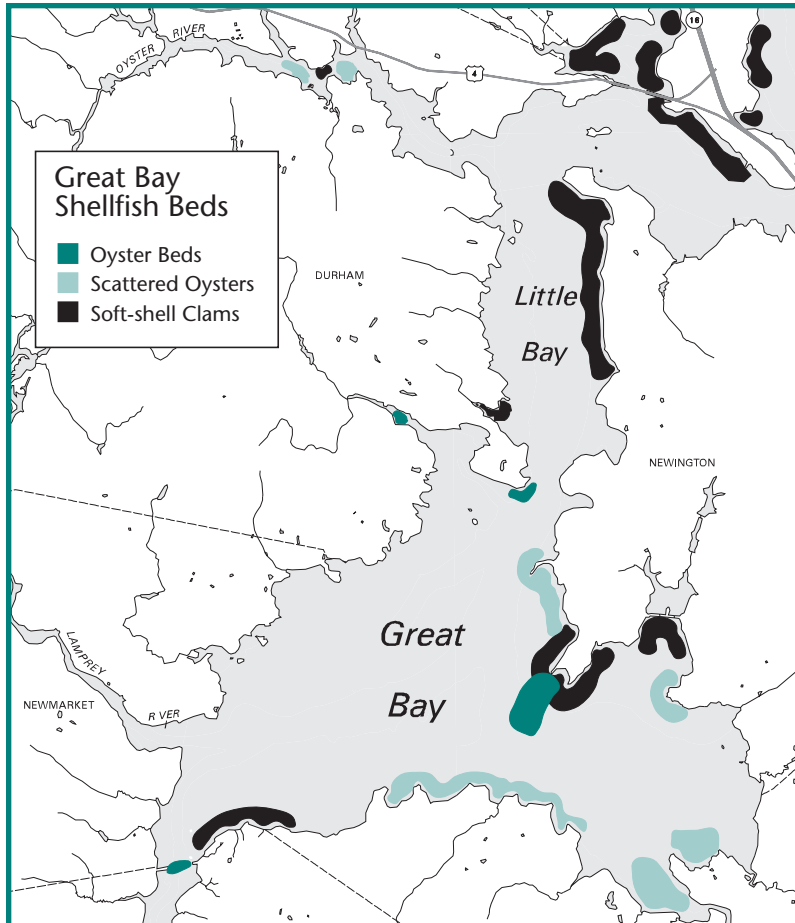


FIGURE 1.3

Shellfish resources in Great Bay, Little Bay, and tributaries.

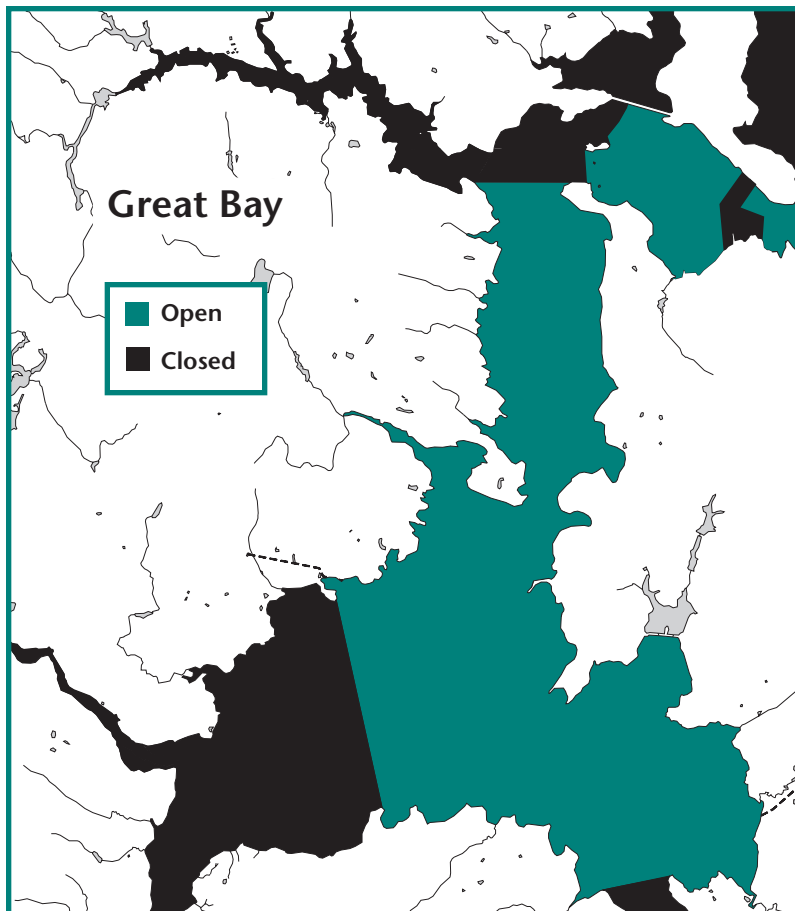


FIGURE 1.4

1998 Shellfish waters classification for the Great Bay Estuary.

FIGURE 1.5

*Hampton/Seabrook
Harbor clam flats*

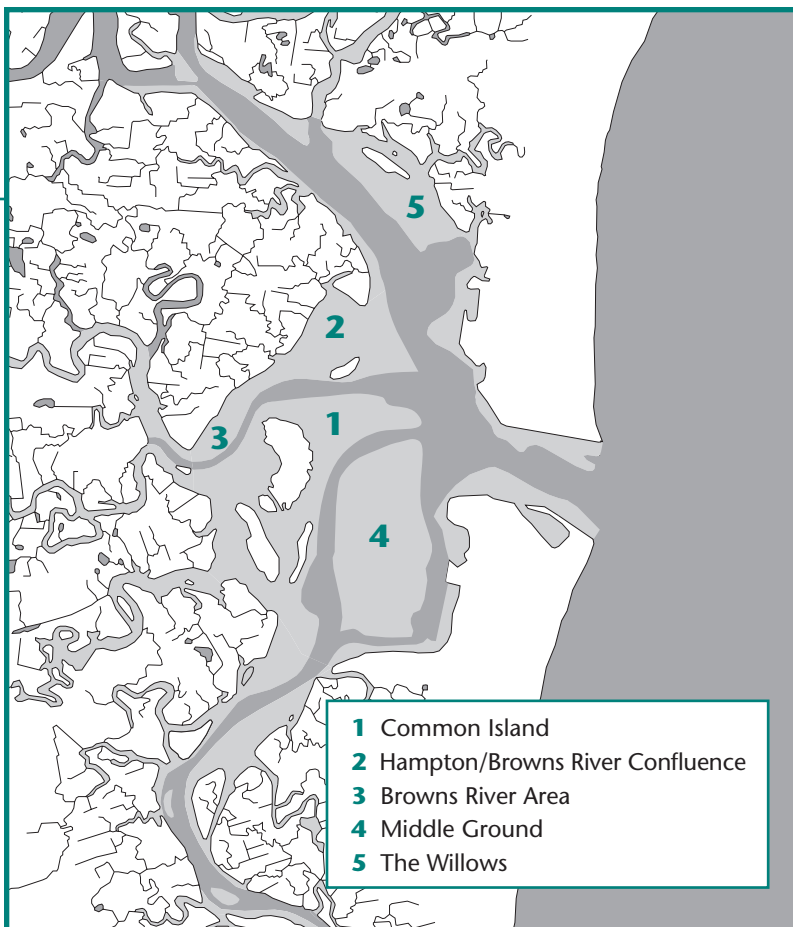
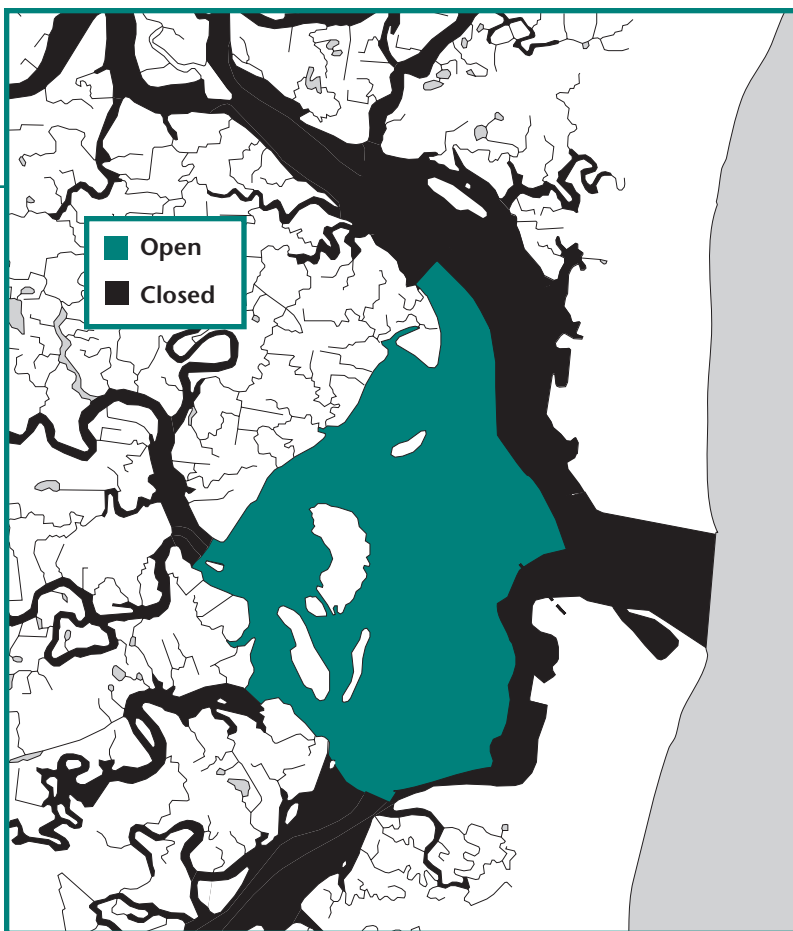


FIGURE 1.6

*1998 Shellfish water
classification for
Hampton/Seabrook
Estuary*



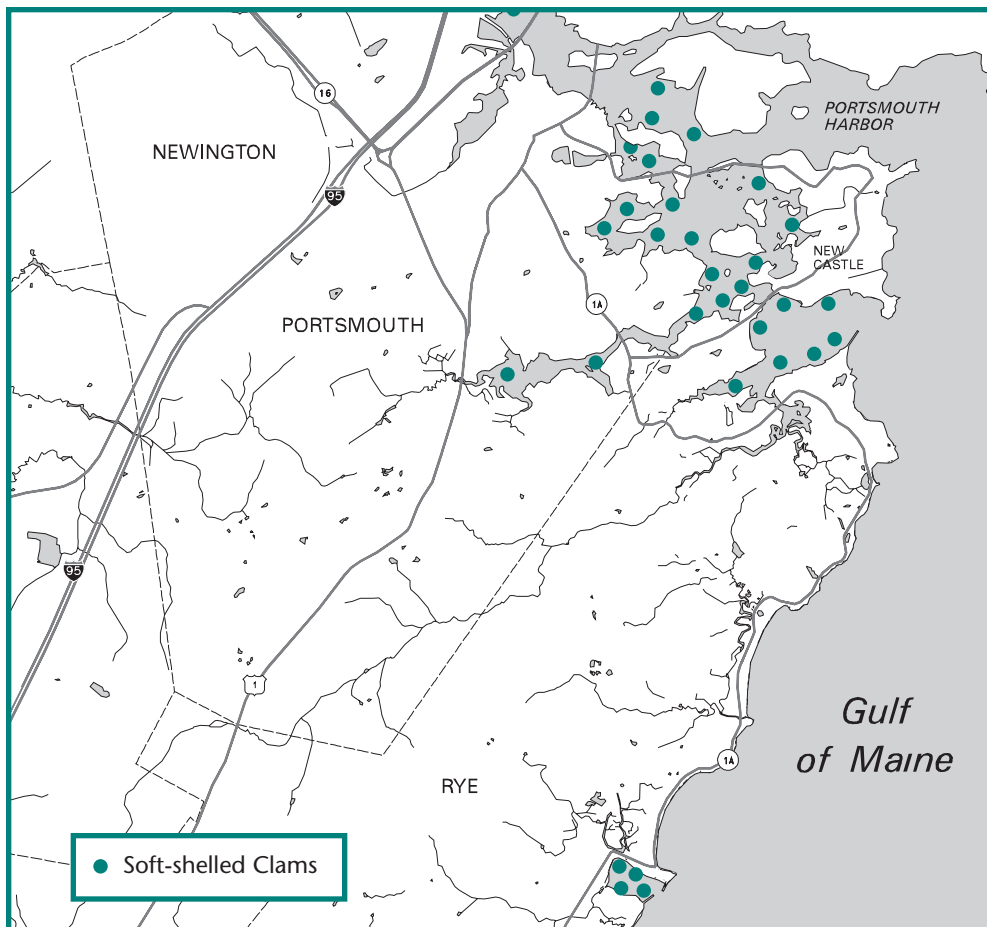


FIGURE 1.7

Shellfish resources in Portsmouth, Rye, and Little Harbors.

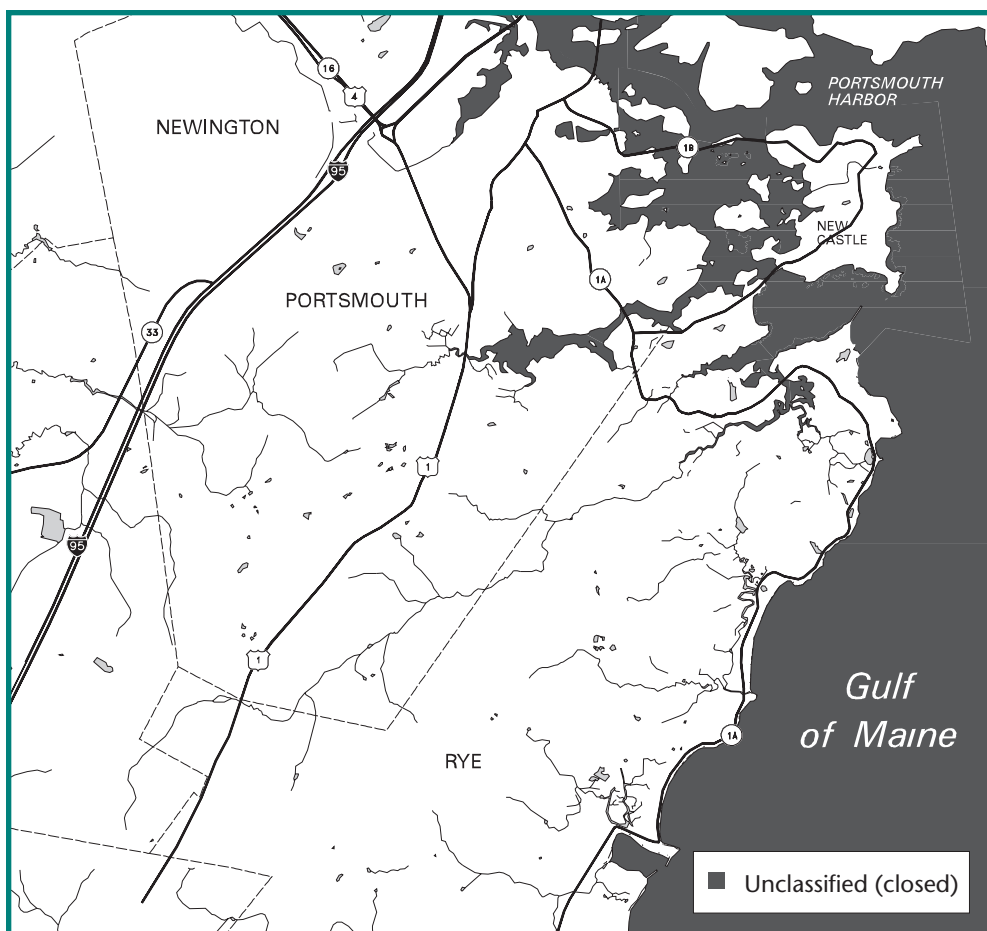


FIGURE 1.8

Shellfish classification for Portsmouth, Rye, and Little Harbors and the northern open coast.

done from the shore in many places and from the bridges crossing the estuary. Several charter boat companies in the Great Bay Estuary take fishermen to pursue striped bass, bluefish, and pollack, while companies operating out of Hampton Harbor carry fishing parties to the offshore waters to pursue cod, bluefish, flounder, mackerel, and other fish. One of the major winter activities in Great and Little Bays is ice fishing for smelt. The smelt fishery in Great Bay occurs primarily in the Greenland Cove, Lamprey River, Squamscott River and Oyster River areas from early January to March. The N.H. Fish and Game Department has pursued stocking and monitoring efforts on selected fish stocks (e.g., shad and Atlantic salmon) in order to enhance recreational fisheries (NHF&G 1989). Another important recreational fishing activity is the trapping of lobsters. Almost 150 recreational lobstermen set traps throughout the Great Bay and Hampton/Seabrook estuaries, with the Portsmouth Harbor area being a popular location.

Studies by N.H. Fish and Game consultants identified substantial sums of monies spent on marine recreational fishing. An estimated 88,000 saltwater anglers spent over \$52 million in 1990 on fishing-related activities (approximately \$600 per person). The largest expenditures were for food and beverages, automobile fuel, charter/ party boat fees, bait and fishing tackle, and boat fuel. A substantial amount of that total is estimated to come from expenditures in Great Bay estuarine activities.

1.3.1.4 Passive Recreation

There are several types of passive recreation that are common in and around the Great Bay and Hampton/Seabrook estuaries. One of the major attractions of New Hampshire's estuaries, particularly Great Bay, is the beautiful scenery. Several large tour boats bring groups into the Bay to see the fall foliage and to enjoy the water views and largely unspoiled shorelines. Fishermen, sportsmen, and boating enthusiasts frequent the estuary year-round. Though the scenic use of Great Bay is enjoyed primarily

by way of boating, a number of public access areas, parks, and nature trails provide sweeping views of the Great Bay Estuary. These areas include:

- Adams Point in Durham
- Cedar Point in Durham
- Hilton Park in Dover
- GBNERR Sandy Point Discovery Center in Stratham
- Chapman's Landing in Stratham
- Prescott Park in Portsmouth
- Bellamy and General Sullivan Bridges in Dover
- Bellamy River Wildlife Management Area in Dover

Numerous state parks exist along the Atlantic coastline from Rye to Hampton, providing swimmers, sunbathers, fishermen, and picnickers with both sandy beaches and rocky shorelines. Several towns around the estuary maintain access and recreation facilities, including Wagon Hill Farm in Durham (Oyster River), Fox Point in Newington (Little Bay), Pierce Island and Prescott Parks in Portsmouth (Piscataqua River), as well as access points in Dover (Cocheco River), Newmarket (Lamprey River), and Exeter (Squamscott River). Historic sites such as Fort Constitution in New Castle, Strawberry Banke in Portsmouth, and Fort McClary and Fort Foster in Maine are also located on the Piscataqua River.

Bird watching by an active seacoast chapter of the Audubon Society, as well as by other groups, is increasing in popularity. A volunteer group now conducts regular surveys of waterfowl, seabirds, songbirds, and raptors for the Great Bay National Estuarine Research Reserve. Great Bay is a favored wintering site for bald eagles, with as many as 15 individual birds having been observed over the course of a winter. Nesting ospreys are also a popular attraction. The opening of the Great Bay National Wildlife Refuge in the fall of 1995 has resulted in increased use of the area for bird watching and enjoyment of nature.

1.3.2 COMMERCIAL RESOURCES AND VALUES

1.3.2.1 Industry and Shipping

Commercial uses of the Great Bay Estuary are primarily concentrated in Portsmouth Harbor and along the New Hampshire side of the Piscataqua River. The Port of New Hampshire in Portsmouth Harbor, a center of deep-water cargo shipping activities including fuel oils, wire cable, cement, scrap metal, salt, gypsum, coal, propane, gasoline, and other products, supports numerous industries located along the lower Piscataqua River. Tonnage for 1992 was just over 4,100,000 tons, with just over half of the total being oil shipments. Additionally, the Portsmouth Naval Shipyard, located on Seavey Island in Portsmouth Harbor, uses the estuary to provide submarine access to repair facilities and for shipping activities.

1.3.2.2 Fishing

Commercial fishing in New Hampshire occurs mainly offshore, and is based in fishing cooperatives in Portsmouth and Seabrook. However, eels, lampreys and baitfish such as silversides, mummichogs and river herring are harvested commercially in the Great Bay Estuary. A substantial commercial lobster fishery exists in the Great Bay Estuary and other coastal waters, with almost 300 lobstermen harvesting nearly 881,300 pounds, valued at approximately \$5-6 million each year. Studies conducted for the Fish and Game Department estimate over \$1.8 million is expended annually by commercial fishing interests.

Several small charter boats take passengers fishing for striped bass, bluefish, and pollack in the Great and Little bays, while charter boats based in Hampton and Seabrook take passengers offshore to pursue cod, flounder, mackerel, and others.

Four commercial shellfish aquaculture operators in the Great Bay Estuary were active in the 1970s and 1980s. The only

shellfish aquaculture business operating today is located in Spinney Creek on the Maine side of the Piscataqua River. However, there has been recent interest in reviving aquaculture in New Hampshire.

1.3.2.3 Tourism and Recreational Industries

Tourism has become a major industry in the New Hampshire Seacoast, and the Seacoast Region is an important area for this industry in the state. Approximately 10 percent of all visitors to New Hampshire come to the Seacoast, exceeded only by the White Mountains and Lakes Regions (Institute for New Hampshire Studies, 1993). The Travel and Tourism industry, which includes businesses such as hotels/motels, marinas and related boating stores, tour boats, retail stores, fishing charter boats, parks and other recreational facilities, and restaurants, supports just over 15 percent of the jobs in the Seacoast, making it the region's second largest industry (Table 1.2). A healthy estuarine system is critical to maintaining this portion of the seacoast economy. In a survey of summer vacationers in 1993, respondents were asked what their "image" of New Hampshire was. The most common responses were "scenic," "clean," and "beautiful" (Institute for New Hampshire Studies, 1993). Closed shellfish beds and other visible signs of pollution, therefore, clearly detract from the estuaries' value to the tourism industry.

Employment in the New Hampshire seacoast economy. Data from Institute for New Hampshire Studies (1993).

TABLE 1.2

Industry	Total Employment (%)
Manufacturing	32.2
Travel and Tourism	15.3
Other Services	15.2
Other Retail	12.1
Government	7.7
Transportation/Public Utilities	7.5
Agriculture/Mining/Construction	7.1
Financial/insurance/Real Estate	2.9